HYDROLOGIC AND HYDRAULIC BASELINE REPORT

Prepared for

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EXECUTIVE SUMMARY

The existing tidally influenced hydraulic system includes the restored Talbert Marsh, Talbert inlet channel, and the Huntington Beach and Talbert flood control channels. Both flood control channels were designed to convey storms with a return period 100 years.

Under dry weather conditions, the hydraulic flows in the existing system are mainly tidal as storm drain low flows are being diverted to the sanitary sewer system for treatment and disposal in the offshore ocean outfall. Both channels are very flat, the tidal flow reaches a dam at Adams Avenue on the Huntington Beach channel, and a rubber dam between Yorktown and Garfield Avenues for low flow diversions on the Talbert Channel. Field tidal measurement and float path and pattern tracking studies were conducted to characterize the existing dry weather hydraulic conditions and provide data for numerical model calibration. The results indicated that the low tides in the Talbert inlet and both flood control channels were significantly muted from, and perched above the ocean low tides. Compared to the ocean tides, the spring low tides were muted by 2 feet in the inlet, and 3.3 feet in the Huntington Beach Channel at Newland Street, and 2.5 feet in Talbert Channel. The phase lags of low tides were 1 hour at the marsh, 4 hours in Huntington Beach Channel and 3 hours in the Talbert Channel. Tidal muting is the result of sedimentation in the inlet and the flood-tidal bar in the Talbert Marsh. The restoration of remaining tidal marsh will increase the tidal prism, and ultimately maintain a larger tidal inlet and enhance the tidal circulation in the Talbert Marsh and the flood control channels.

The float tracking results indicate that seawater conveyed into Talbert Marsh from the ocean fills the marsh and moves upstream through the flood control channel system. Seawater preferentially moves into the Talbert Channel and secondarily moves in the Huntington Beach Channel due to the larger cross-section and resulting tidal prism and tidal draw in Talbert Channel. Seawater is conveyed farther upstream on the Talbert Channel with higher-high tides and reached beyond Adams Avenue on spring high tide, but only reached to Atlanta on the lower-high tide of the day. Seawater is conveyed to Adams Avenue on the Huntington Beach Channel during higher-high tides and to within 2,000 feet south of Atlanta Street during lower-high tides. Seawater is effectively conveyed to the sea from the marsh during spring ebbing tides, while the Talbert Channel also drains effectively to the sea but Huntington Channel may not drain as efficiently and portion of water may remain in the system rather than being conveyed to the sea.

Under the 100-year storm, during the ocean spring high tide at +6.64 ft NAVD88 (assuming conditions reflect the most recent bridge cross-section survey), model results suggest that the peak water level at the upstream side of Brookhurst Bridge reach +8.5 feet above the NAVD88 datum, which is half a foot higher than the bridge soffit. Flood flows remain in the channel as the levee and berm both are elevated above the flood elevation. The hydraulic conveyance of the bridge cross-section has increased compared to the as-built condition since the recent survey shows that the channel thalweg is scoured by more than 3.5 feet from an elevation of +0.44 shown in the as-built plans to –3.2 ft.

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1.0 INTRODUCTION

Huntington Beach (HB) wetlands are a relic wetland area in the vicinity of the former Santa Ana Rivermouth. Over time, wetlands were filled for development, infrastructure, and refuse disposal, and used for oil drilling, gas extraction and other purposes. They were isolated from the ocean by construction of Pacific Coastal Highway (PCH) and by the Santa Ana River Flood Control levees. Approximately 180 acres remain of the former larger wetland. The wetlands consist of degraded salt marsh, seasonal ponds, and coastal dune habitat, with 25 acres of restored marsh (Talbert Marsh). Unrestored areas of the HB wetlands consist of non-tidal salt marsh vegetation that varies from relatively poor to moderate quality. The study area for the Huntington Beach Wetlands Restoration Plan (HBWRP) extends from the Santa Ana River to Beach Boulevard, and includes flood control channels and the Talbert Marsh inlet as shown in Figure 1.

The purpose of this Task 4 study is to evaluate the existing hydrologic and hydraulic conditions and create a numerical model to characterize the hydraulic flow patterns. The model will also be used in evaluating the tidal regime for various restoration alternatives in Task 9 after restoration alternatives based on opportunities and constraints are developed. Existing hydrology and hydraulic data and studies were reviewed for this effort. Tidal fluctuations in the Talbert Inlet, and Huntington Beach and Talbert Flood Control Channels were measured. Tidal flow patterns and paths were also observed and estimated in the field by tracking floating objects to map currents. In addition, a finite element RMA2 numerical model was constructed to model tidal and flood hydraulics for the existing hydraulic system, and under a storm event with a return period 100 years.

2.0 EXISTING HYDRAULIC SYSTEM

The Talbert Marsh drainage area is approximately 8,600 acres (13.5 square miles), and includes portions of the City of Huntington Beach and Fountain Valley. The Talbert Channel Watershed has mild slopes with elevations ranging from sea level to about 130 feet above mean sea level. Surface runoff is collected in three main flood control channels. The Talbert Channel drains the southern and central portions of the watershed and empties into the Talbert Marsh. The Fountain Valley Channel drains about 3.9 square miles of area and joins with the Talbert Channel fairly high up in the watershed. The Huntington Beach Channel drains about 4.3 square miles in the northern portion of the watershed and joins the Talbert Channel just upstream of Brookhurst Street bridge. Because of the mild slopes a system of pump stations has been constructed to convey runoff from the catch basins to the flood control channels.

The existing tidally influenced hydraulic system includes the restored Talbert Marsh, Talbert inlet channel (ocean connection under PCH), Talbert Channel (D02) and the Huntington Beach Channel (D01). The remaining wetlands in the project area are not currently connected to the existing hydraulic system except by two 2-foot diameter culverts with flap gates, one of which connects a small marsh north of the AES Plant to the Huntington Beach Channel and the other which connects Newland marsh to the same channel. However, the flow quantities are small compared to the flows in the flood control channel and one of the pipes may be an illicit connection, so they were neglected in the existing hydraulic modeling and analyses.

Under dry weather conditions, the hydraulic flows in the existing system are mainly tidal as storm drain low flows are being diverted to the sanitary sewer system for treatment and disposal in the offshore ocean outfall. Both flood control channels are very flat allowing the tidal flow to reach a dam at Adams Avenue for Huntington Beach channel, and a rubber dam between Yorktown and Garfield for low flow diversions for Talbert Channel.

Under wet weather conditions, the channels receive runoff from the Talbert watershed. Both channels were constructed to convey 100-year storm flows.

A 100-year storm event and a typical spring high tidal elevation of 6.64 ft relative to the vertical datum of NAVD88 (+4.2 ft, NGVD29 or mean sea level) at the ocean boundary are used in assessing flood flow impacts to Brookhurst Street and PCH Bridges.

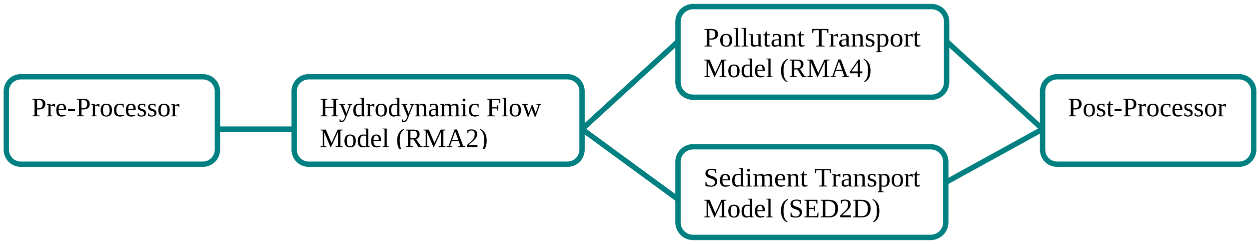
3.0 MODEL SELECTION AND DESCRIPTION

The numerical modeling systems used in this study are summarized in the following sections.

The TABS2 (McAnally and Thomas, 1985) modeling system was developed by the U.S. Army Corps of Engineers (USACE), and consists of two-dimensional, vertically averaged finite element hydrodynamics (RMA2), pollutant transport/water quality (RMA4) and sediment transport models (SED2D). TABS2 is a collection of generalized computer programs and pre- and post-processor utility codes integrated into a numerical modeling system for studying two-dimensional (2-D) depth-averaged hydrodynamics, transport and sedimentation problems in rivers, reservoirs, bays, and estuaries.

The finite element method provides a means of obtaining an approximate solution to a system of governing equations by dividing the area of interest into smaller sub-areas called elements. Time-varying partial differential equations are transformed into finite element form and then solved in a global matrix system for the modeled area of interest. The solution is smooth across each element and continuous over the computational area. This modeling system is capable of simulating tidal wetting and drying of marsh and intertidal areas of the estuarine system.

A schematic representation of the system is shown on the following page. TABS2 can be used either as a stand-alone solution technique or as a step in the hybrid modeling approach. RMA2 calculates water surface elevations and current patterns which are input to the pollutant transport (RMA4) and sediment transport (SED2D) models. Existing and proposed geometry can be analyzed to determine the impact of project designs on flow circulation, salinity, water quality and sedimentation in the estuary system. All models utilize the finite element method with Galerkin weighted residuals.



TABS2 Schematic

The hydrodynamic model simulates 2-D flow in rivers and estuaries by solving the depth-averaged Navier Stokes equations for flow velocity and water depth. The equations account for friction losses, eddy viscosity, Coriolis forces and surface wind stresses. The general governing equations are:

Continuity equation:

$$\frac{\partial h}{\partial t} + \frac{\partial\,(hu)}{\partial x} + \frac{\partial\,(hv)}{\partial y} = 0$$

Conservation of momentum equations:

$$h\frac{\partial u}{\partial t} + uh\frac{\partial u}{\partial x} + vh\frac{\partial u}{\partial y} + gh\frac{\partial a}{\partial x} + gh\frac{\partial h}{\partial x} - h\frac{\varepsilon_{xx}}{\rho}\frac{\partial^2 u}{\partial x^2} - h\frac{\varepsilon_{xy}}{\rho}\frac{\partial^2 u}{\partial y^2} + S_{f_x} + \tau_x = 0$$

$$h\frac{\partial v}{\partial t} + uh\frac{\partial v}{\partial x} + vh\frac{\partial v}{\partial y} + gh\frac{\partial a}{\partial y} + gh\frac{\partial h}{\partial y} - h\frac{\varepsilon_{yx}}{\rho}\frac{\partial^2 v}{\partial x^2} - h\frac{\varepsilon_{yy}}{\rho}\frac{\partial^2 v}{\partial y^2} + S_{f_y} + \tau_y = 0$$

where:

u,v = x and y velocity components

t = time

h = water depth

a = bottom elevation

Sf_x = bottom friction loss term in x-direction

Sf_y = bottom friction loss term in y-direction

τ_x = wind and Coriolis stresses in x-direction

τ_y = wind and Coriolis stresses in y-direction

ε_{xx} = normal eddy viscosity in the x-direction on x-axis plane

ε_{xy} = tangential eddy viscosity in the x-direction on y-axis plane

ε_{yx} = tangential eddy viscosity in the y-direction on x-axis plane

ε_{yy} = normal eddy viscosity in the y-direction on y-axis plane

For this study, the RMA2 hydrodynamic model was applied.

4.0 MODEL SETUP

Setup for the tidal and flood hydraulic model for existing conditions included determination of the model area, bathymetry, mesh selection, and boundary conditions.

4.1 MODEL AREA

The model area covers the restored Talbert Marsh, Talbert tidal inlet channel, Talbert Channel (D02) from the Talbert Marsh to the rubber dam located between Yorktown and Garfield and Huntington Beach Channel (D01) from the confluence with the Talbert Channel to a dam at Adams Avenue. The model mesh covers a relatively large area. The offshore open boundary (at a contour elevation of -50 feet relative to the NAVD88 vertical datum) is approximately one and a half miles from the Talbert tidal inlet. Designating the open model boundaries far from the area of interest minimizes boundary effects during model simulations.

4.2 BATHYMETRY

The Talbert Marsh bathymetry was based on a July 2004 survey conducted by Dulin & Boynton Licensed Surveyors, Inc. under a subcontract to Moffatt & Nichol for the Huntington Beach Wetlands Conservancy (HBWC). Both Flood Control Channels' bathymetry was provided by the Orange County Resources and Development Management Department (OCRDMD). The offshore bathymetry was based on beach profiles (USACE 1997). However, no recent survey data are available for the Talbert Inlet. The inlet invert is adjusted during the model calibration to match results to water levels at PCH Bridge measured during this study period with a tide gage. The inlet is located in a sediment abundant environment with inlet dimensions designed to accommodate a 100-year storm event, but not necessarily to be stable during non-flood conditions. Therefore, the inlet is relatively wide and experiences significant shoaling throughout most of the year. The County periodically removes sediment from the channel to restore its flood conveyance capability. The inlet is relatively stable and typically remains in an open condition. For the baseline hydraulic analyses under the 100-year storm event, the design inlet dimensions were applied in the model since the inlet cross-section will be scoured and widened to the design cross-section before the peak of the 100-year storm arrives the inlet.

The project uses the NAD 83 California Zone 6 horizontal coordinate system and the NAVD88 vertical datum. English units (feet, feet per second, etc.) are used throughout the model study.

4.3 MODEL MESH

The RMA2 model requires the estuarial system to be represented by a network of nodal points defined by coordinates in the horizontal plane and water depth, and elements created by connecting these adjacent points to form areas. Nodes can be connected to form 1- and 2-dimensional (2-D) elements, having from two to four nodes. The resulting nodal/element network is commonly called a finite element mesh and provides a computerized representation of the estuarial geometry and bathymetry. The results discussed herein correspond to 2-D analyses since they are depth averaged.

The two most important aspects to consider when designing a finite element mesh are: (1) determining the level of detail necessary to adequately represent the estuary, and (2) determining the extent or coverage of the mesh. The model described in this section is numerically robust and capable of simulating tidal elevations, flows, and constituent transport with reasonable resolution. Accordingly, the bathymetric features of the estuary generally dictate the level of detail appropriate for the mesh.

There are several factors used to decide the aerial extent of a mesh. First, it is desirable to extend mesh open boundaries to areas which are sufficiently distant from the proposed areas of change so as to be unaffected by that change. Additionally, mesh boundaries must be located along sections where conditions can reasonably be measured and described to the model. Finally, mesh boundaries can be extended to an area where conditions have been previously identified to eliminate the need to interpolate between the boundary conditions from other locations.

The finite element mesh for the existing condition is shown in Figure 2. The mesh contains a section of ocean sufficiently large to eliminate potential model boundary effects. The marsh portion of the mesh is bounded by the +10 foot contour relative to the vertical datum of NAVD88 considered to sufficiently contain the outermost extents of tidal and flood influence. The marsh area mesh is shown in Figure 3.

The entire modeling area, approximately 4 square miles, is represented as a finite element mesh consisting of about 2,400 elements and 7,000 nodes.

4.4 BOUNDARY CONDITIONS

4.4.1 Tides

As no continuous tide monitoring station exists at Huntington Beach, the nearest Los Angeles Outer Harbor tidal gage monitored by NOAA was used as the ocean boundary tidal condition and data are shown in Table 1. The diurnal tide range is approximately 5.49 feet from Mean Lower Low Water (MLLW) to Mean Higher High Water (MHHW) and Mean Sea Level (MSL) is at +2.82 feet relative to MLLW.

Water level measurement data provide astronomical tides and other components including barometric pressure tide, wind setup, seiche, and the El Nino Southern Oscillation. Tidal variations can be resolved into a number of sinusoidal components having discrete periods. The longest significant periods, called tidal epochs, are approximately 19 years. In addition, seasonal variations in MSL can reach amplitudes of 0.5 feet in some areas, such as Los Angeles Outer Harbor. Superimposed on this cycle is a 4.4-year variation in the MSL that may increase the amplitude by as much as 0.25 feet in San Pedro Bay. Water level measurement data are typically analyzed over a tidal epoch to account for these variations and obtain statistical water level information (e.g., MLLW and MHHW) useful for hydrology analyses.

Table 1. Recorded Water Levels at Los Angeles Outer Harbor (1983-2001 Tidal Epoch)

Description	Elevation (feet, MLLW)	Elevation (feet, NAVD88)
Extreme High Water (1/27/83)	+7.82	+7.62
Mean Higher High Water (MHHW)	+5.49	+5.29
Mean High Water (MHW)	+4.75	+4.55
Mean Tidal Level (MTL)	+2.85	+2.64
Mean Sea Level (MSL)	+2.82	+2.62
National Geodetic Vertical Datum 1929 (NGVD29)	+2.64	+2.44
Mean Low Water (MLW)	+0.94	+0.74
North America Vertical Datum-1988 (NAVD88)	+0.20	+0.0
Mean Lower Low Water (MLLW)	0.00	-0.2
Extreme Low Water (12/17/33)	-2.73	-2.93

4.4.2 Tidal Epoch Analysis (TEA) Tidal Series

The TEA tide is a synthetic 14-day tidal series developed statistically to match the cumulative distribution of water levels over a 19-year tidal epoch (1960-1978). The TEA tide includes both spring and neap tidal ranges as shown in Figure 4. Ideally, the latest tidal epoch data would best represent future conditions and therefore could be used to model long-term conditions. However, performing simulations using 19 years of water level data for each computer run is impractical. By using the TEA tide for hydrodynamic modeling, long-term tidal variations can be modeled with relatively small computation times. The hydraulic modeling results predict long-term water level distribution and tidal inlet hydraulics. The spring high tidal cycle with a tidal elevation of +6.64 ft NAVD88 (+4.2 ft nGVD29) is applied at the ocean boundary as the downstream control elevation in evaluating hydraulics under the 100-year storm event.

4.4.3 Flood Control Channel Hydrographs

Flood hydrographs developed for the Brookhurst Street bridge improvement project over the Talbert Channel (RBF, May 1987) were used in the study as a more recent hydrologic study was not available. However, the peak flow rates in the 100-year hydrograph from HEC-1 model results were lower than the peak flow rates recommended in the report in text for both flood control channels. Therefore, the hydrographs were raised up by a ratio of 1.200 and 1.003, respectively, for Huntington Beach and Talbert Channels to match the recommended 100-year peak flow rates. The peak flow rates are 2,680 and 3,695 cubic feet per second (cfs), respectively, for Huntington Beach and Talbert Channels. The hydrographs are shown in Figures 5 and 6.

5.0 MODEL CALIBRATION

RMA2 calibration involves matching model predictions with measured data by selecting appropriate input variable values to the model [e.g., Manning’s roughness coefficient (n), and turbulence exchange coefficients (eddy viscosity)].

The RMA2 User’s Manual recommends ranges of values for Manning’s roughness coefficient (n) and eddy viscosity to be used in the model (USACE WES, 1996b). The value of Manning’s roughness coefficient (n) is a function of the characteristics of the hydraulic system and represents the roughness of the channel bed. As discussed in Chaudhry (1993), values can range from 0.011 to 0.075 or higher for natural rivers and estuaries. Relatively high values (0.04 to 0.05) are specified for rough surfaces, such as channels with cobbles or large boulders. Mid-range values (0.03) represent clean and straight natural streams. Low values (0.013 to 0.02) are specified for smooth surfaces, such as concrete, cement, wood, or gunite. Values of Manning’s roughness coefficient (n) used for this analysis are in the middle range of the recommended values.

Eddy viscosity represents the degree of turbulence in the flow. In this application, the values range from 50 to 300 lb-sec/ft^2. The modeling grid size depends on and is limited by the Peclet number and eddy viscosity. The Peclet number is defined as $\frac{\rho V \Delta X}{E_{ij}}$, in which ρ, V, ΔX, and E_{ij} are the water density, velocity, grid size and eddy viscosity, respectively. In order for the solution to be stable, the Peclet number has to be less than 50. The Peclet number can be reduced by increasing the mesh density or by increasing the eddy viscosity. However, it is unrealistic and time-consuming to perform the modeling with a very fine grid. Therefore, a relatively high value of eddy viscosity is used in order to preserve numerical stability, and to streamline the modeling efforts.

Two tide gages were deployed on July 30 and one on July 31, 2004 to record a complete large/typical spring and neap tidal cycle at PCH Bridge at the Talbert inlet, Banning Avenue Bridge at the Talbert Channel and Newland Street Bridge at the Huntington Beach Channel as shown in Figure 7. The gages were left in place for a period of two weeks to record complete neap and spring tidal cycles, and were retrieved on August 16, 2004. The purpose of the tide monitoring was to characterize the existing dry weather tidal hydraulic conditions in the existing marsh and channel systems, and to provide data for numerical model calibration. Gages were Brancker models TG-205 (two) and DR-1050 P (one). They were anchored on the bridge pile at PCH several feet above the inlet bed, and on fence posts in the flood channels just 6 inches above the bed. Results are presented in the following section.

The time step is a very important parameter in the modeling. Sensitivity tests were conducted and results showed that the RMA2 model becomes unstable with an increasing time step if the wetting and drying processes are considered. A time step of 0.1 hour was used in order for the solution to be stable and to reflect the dynamic tidal fluctuations and the flood flow hydrograph.

As previously discussed, the Talbert inlet cross-section invert was adjusted in the model calibration to match water levels recorded in the tidal inlet with water levels simulated by the model since the inlet is a dynamic system. During a separate two-week tidal measurement tidal period in May 2000 at the inlet, the inlet invert rose more than one foot during neap tides (M&N 2001). Model calibration results will be provided in the future report of alternatives analyses.

6.0 BASELINE HYDRAULIC CONDITIONS

6.1 DRY WEATHER CONDITION

Under the dry weather condition, typically from May to October, the local storm drains are diverted to the sewer system except very low flows from behind the AES plant and the Newland Marsh via two foot diameter culverts with flapgates and two private pumps to the

Huntington Beach Channel. The two private pumps are from the Huntington-by-the-Sea Mobile Home Park pump collecting nuisance flows from a 49-acre site and Chevron Oil Tank Yard pump collecting nuisance flows from a 25-acre site. These flow quantities are small compared to tidal flows in the flood control channel. Groundwater levels in the project area are lower than the average tidal elevations in the channel, so the channels are recharging the groundwater. Tidal flows dominate the existing hydraulic system.

6.1.1 Measured Tides

In order to characterize the existing hydraulic system, three tide gages shown in Figure 7 were deployed for a period of two weeks as mentioned in Section 5.0. The recorded tidal series together with that predicted at the Los Angeles Outer Harbor by the National Oceanic and Atmospheric Administration (NOAA 2004) are shown in Figure 8.

Results indicate the spring low tides, as shown in Figure 9, at PCH bridge over the tidal inlet were perched above the ocean low tides by about 2.5 feet, and the time lag to slack water between the marsh and the ocean was about 2 hours. The high tide elevation at PCH Bridge nearly reaches that of the ocean tide, however, with a 15-minute time lag. The tides were further muted in the upstream channels. The spring high tides at Banning Avenue Bridge at Talbert Channel were muted about one tenth of foot and the time lag was 18 minutes compared to the ocean tides. The low spring tides were muted more than 3 feet, and the time lag was about 3 hours. For the Huntington Beach Channel at Newland Street, the spring high and low tides were muted about 0.5 ft and 3.3 ft, respectively, and their time lags were half an hour and four hours.

Tidal elevations in the flood channels are sufficient to perform restoration of the marsh as they will flood the existing marsh surface during spring high tides if the berm was breached. However, mean sea level in the channel is lower than the majority of the marsh area suggesting that feeder channels will need to be installed in the restored marshes to convey seawater from the flood control channels.

The tidal muting in the Talbert Marsh is caused by the significantly shoaling at inlet and the growing flood bar in the marsh. These results further indicate that the existing tidal prism is sufficient to maintain a stable tidal inlet under the dry weather condition, but the inlet is not sufficient in cross-sectional area to convey the full ocean range to the marsh. The marsh only receives a portion (slightly more than one-half) of the full ocean tide range. The ramifications of this are that restoration needs to be done either in anticipation of this condition, or needs to be done in a way that increases the tide range experienced at the marsh by increasing the wetland tidal prism and removing portions of the flood bar.

6.1.2 Float Tracking Study

A field float tracking study was performed by HBWC staff and consultants to map and document tidal flow hydraulics from the ocean through the marsh and the flood channel system. These data provide further clarification of the tidal action within the existing system and will serve as calibration data for the numerical model. Oranges were used as floats as they are buoyant and visible, and present minimal surface area above the water surface to be influenced by wind. They are also biodegradable if lost.

The field plan consisted of placing oranges into the center of the tidal inlet at slack water prior to the incoming tide to observe and map tidal penetration upstream within the flood control channels. Spring low tide was at approximately 4:30 AM, with the following high tide at approximately 10:30 AM. The morning low tide (4:30 AM) was the day’s lower-low tide, rising to the lower-high tide of that day (at 10:30 AM). Tides would drop again to a higher low tide at 3:30 PM, followed by the higher high tide of the day at approximately 9:30 PM. One goal was to document if the oranges traveled farther upstream during the higher-high tide than the lower-high tide, and to quantify their distance of travel and average velocities. Another goal was to map the distribution of oranges within the marsh during incoming tides, and their return travel paths during outgoing tides.

Flooding Tide in the Morning

Slack water at the inlet occurred at approximately 7:40 AM, although the ocean tide was visibly rising since the field team’s arrival at 6 AM from the 4:30 AM low tide. The lag in time of tidal action between the tidal inlet and the ocean is significant for tidal flushing of the marsh and is discussed elsewhere in this report. Twelve oranges (numbered 1 through 12 with indelible ink) were deployed at the tidal inlet at 7:40 AM and were followed into the marsh, with the exception of one orange that was damaged and discarded leaving eleven oranges to track through the rising tide in the morning.

Five of the eleven oranges moved into the eastern portion of Talbert Marsh upon entering the rear (north) channel closest to the pedestrian/bike path. The remaining seven oranges were carried north and west toward Brookhurst Street bridge, and steadily traveled through the marsh and into Talbert Channel under the bridge. All seven oranges were transported northwest along the north flood control channel sheetpile levee and into Talbert Channel at the confluence of both flood control channels. No oranges were transported west into the Huntington Beach Channel. Oranges traveled upstream on the Talbert Channel to Atlanta Street, a distance of 1.5 miles from the ocean. Movement ceased and upstream orange transport ended by 11:30 AM at Atlanta Street.

Since no oranges moved into Huntington Beach Channel, the team deployed two oranges just upstream of the channel confluence and tracked them upstream to between Newland Street and Atlanta. The oranges ceased moving by 12:00 PM. Figure 10 shows the orange movement during this tide cycle.

Ebbing Tide in the Afternoon

Slack tide at Talbert Marsh occurred at approximately 11 AM, after which the marsh and flood channels began to drain to sea. All oranges were transported downstream and those in Talbert Channel near Atlanta Street moved under Brookhurst Street and were beached within the marsh on sand bars or within eelgrass stands. A deeper-water channel (thalweg) exists along the south side of the main channel in the marsh near Brookhurst Street that continuously drained to the ocean, and none of the oranges were carried into this channel. All moved along a straight course downstream of the bridge to sand bars. All oranges that deposited in west Talbert Marsh, except one, were dislodged and either moved to the ocean or toward the tidal inlet channel. One remained in the east marsh. Only two oranges were lost to sea. The oranges in the Huntington Beach Channel remained in the channel and moved to just downstream of Magnolia Street. Figure 11 shows the orange movement during this tide cycle.

Flooding Tide in the Evening

Six oranges were deployed at the tidal inlet at 4:30 PM and tracked into the marsh. All oranges, except one, moved west through the marsh toward Brookhurst Street. One orange moved into the marsh and was carried east into its eastern portion. All oranges that were beached or stranded within the marsh from the morning deployment were remobilized and carried upstream through the marsh toward Brookhurst Street.

All oranges at the west marsh were transported through Talbert Channel along the north sheetpile wall toward the channel confluence, and took a course northwestward into Talbert Channel. No oranges entered the Huntington Beach Channel. However the team threw three oranges into this channel at the confluence for tracking but were unable to track their movement due to logistical difficulties. Oranges in Talbert Channel were tracked progressively upstream and eventually reached Adams Avenue Bridge at 9:30 PM. Motion ceased at 10 PM indicating slack tide in the Talbert Flood Control Channel. Slack tide at Talbert Marsh was not observed, but likely occurred approximately one-half hour prior to that in the Talbert Channel. The field effort ceased at the nighttime slack tide as visibility became prohibitive to observations. Figure 12 shows the orange movement during this tide cycle.

Results of the Float Tracking Study

The fruit drop indicated that tidal hydraulics of the Talbert Marsh are significantly influenced by the effects of the ocean tidal inlet, an obvious point, and are influenced to a greater extent by Talbert Channel than Huntington Beach Channel. Tidal flows entering the marsh from the ocean split and pass both east and west into the main body of the marsh. The majority of tidal flow moves west into areas of greater tidal prism.

Moderate flooding tides caused by only a relatively small tide rise (4 foot rise from low tide to high tide, such as the observed rising morning tide on July 31, 2004) are nearly evenly distributed toward both the east and west portions of the marsh. This point was evidenced by 5 of the 11 oranges in the morning moving into the east marsh and the remaining 6 entering the west marsh.

Also, flooding tides entering the flood control channel system preferentially move into Talbert Channel as opposed to Huntington Beach Channel. This could be due to a larger tidal prism and tidal draw of seawater into Talbert Channel. This condition occurred for both flood tide cycles witnessed during the field effort.

Ebbing tides pass through the system and essentially reach the ocean as evidenced by the oranges all returning to the marsh before being beached or deposited in shallow bar areas.

More powerful flooding tides (5 foot rise or more from low tide to high tide, such as the observed rising evening tide on July 31, 2004) preferentially convey seawater into the western Talbert Marsh through the main channel. This was evidenced by five of the six oranges deployed at the inlet moving west and one moving east. Seawater moving upstream into the flood control channel network preferentially moves into Talbert Channel and tides penetrate farther upstream as the tidal elevation increases. Tides were observed upstream of Adams Avenue Bridge, but floats did not pass this point. It is assumed that all oranges were conveyed downstream during the subsequent ebbing tide back to the marsh although this was not observed due to poor visibility at night.

Tidal flow moves through the Huntington Beach Channel and penetrates upstream to nearly Atlanta Street on moderate flooding tides. Although unverified, tides penetrate upstream to Adams Avenue on more powerful flooding tides.

Figure 13 is a matrix of orange deployment and movement and shows that the fruit moved upstream directly in Talbert Channel on both incoming tides on July 31, 2004, but the flows of the higher high tide moved the fruit farther upstream than the lower high tide.

6.2 100-YEAR STORM FLOOD CONDITION

Model calibration is on-going being performed as stated in report Section 5.0. For the 100-year flood flow hydraulic analyses, modeling coefficients are assigned based on manual recommendations and the engineer’s extensive past RMA2 model application experience. Also, the RMA2 model is relatively robust to those coefficients. In addition, the tidal inlet geometry will vary under the 100-year storm condition, as the inlet will be scoured and some of the sediment eroded from the flood bar and inlet will be transported out to the ocean before the peak of 100-year storm flood arrives. Therefore, the design tidal inlet dimensions were used in the storm hydraulic analyses since sedimentation modeling is beyond the scope for this conceptual study. The modeling results are sufficiently accurate to set a hydraulic baseline condition for alternatives comparison.

The modeling results are summarized in Table 2. The results show flood flow velocities are relatively low, but water levels are relatively high. The water level at Brookhurst Street Bridge is 8.5 ft NAVD88, and is approximately one-half a foot higher than the bridge soffit elevation of 8.04 feet. However, the water is contained within the channel levee since the west side levee elevation is approximately 10 feet above the datum. The July 2004 survey shows that the thalweg under the Brookhurst Bridge is at –3.2 ft NAVD88. This compares to the design channel invert of +0.44 ft NAVD88, showing the channel may have scoured more than 3.5 feet since construction, unless construction varied from the design.

The modeling results will be compared to the bridge design hydraulics as soon as hydraulic and bridge scour analyses reports are obtained from the County.

Table 2. Hydraulic Results Under a 100-Year Storm

Locations	Peak Velocity (fps)	Water Level (ft, NAVD88)
PCH Bridge	4.7	6.9
Brookhurst Bridge	4.8	8.5
Magnolia Bridge	3.5	10.2

7.0 SUMMARY

Existing hydrology and hydraulic studies were reviewed. The existing tidally influenced hydraulic system includes the restored Talbert Marsh, Talbert tidal inlet channel, Huntington Beach and Talbert Channels. Both flood control channels were designed to convey storms with a return period of 100 years.

Under dry weather conditions, the hydraulic flows in the existing system are mainly tidal as storm drain low flows are being diverted to the sanitary sewer system for treatment and disposal in the offshore ocean outfall. Both channels are very flat, the tidal flow reaches a dam at Adams Avenue on the Huntington Beach channel, and to the rubber dam between Yorktown and Garfield Avenues for low flow diversions from Talbert Channel. Field tidal measurement and float path and pattern tracking studies were conducted to characterize the existing dry weather hydraulic conditions and provide data for numerical model calibration. The results indicate that the tides in the Talbert inlet and both flood control channels were significantly muted from the ocean as shown in Table 3. This muting is mainly due to sedimentation in the tidal inlet and the flood-tidal bar in Talbert Marsh. Muting can be reduced by restoring the marsh to increase tidal prism and inlet scouring capability, and by removing portions of the flood-tidal delta in the marsh.

Table 3. Tidal Muting and Phase Lags Compared to the Ocean Tides

Locations	Spring Low Tide		Spring High Tide	
	Muting (ft)	**Phase Lag (hrs)**	**Muting (ft)**	**Phase Lag (hrs)**
Inlet at PCH Bridge	2.5	2	0	0.25
Talbert Channel at Banning Ave.	3	3	0.1	0.30
Huntington Beach Channel at Newland St.	3.3	4	0.5	0.5

Tidal elevations in the flood channels are sufficient to perform restoration of the marsh as they will flood the existing marsh surface during spring high tides if the berm was breached. However, mean sea level in the channel is lower than the majority of the marsh area suggesting that feeder channels will need to be installed in the restored marshes to convey seawater from the channels.

The float tracking results indicate that seawater conveyed into Talbert Marsh from the ocean fills the marsh and moves upstream through the flood control channel system. Seawater preferentially moves into the Talbert Channel and secondarily moves in the Huntington Beach Channel due to the larger cross-section and resulting tidal prism and tidal draw in Talbert Channel. Seawater is conveyed farther upstream on the Talbert Channel with higher- high tides and reached beyond Adams Avenue on spring high tide, but only reached to Atlanta on the lower-high tide of the day. Seawater is conveyed to Adams Avenue on the Huntington Beach Channel during higher- high tides and to within 2,000 feet south of Atlanta Street during lower-high tides. Seawater is effectively conveyed to the sea from the marsh during spring ebbing tides, while the Talbert Channel also drains effectively to the sea but Huntington Channel may not may not drain as efficiently and water may remain in the system rather than being conveyed to the sea.

Under the 100-year storm, during the ocean spring high tide at +6.64 ft NAVD88 (assuming conditions reflect the most recent bridge cross-section survey), model results suggest that the peak water level at the upstream side of Brookhurst Bridge reaches +8.5 feet above the NAVD88 vertical datum, which is half a foot higher than the bridge soffit. Flood flows remain in the channel as the levee and berm both are elevated above the flood elevation. The hydraulic conveyance of the bridge cross-section has increased compared to the as-built condition since the recent survey shows that the channel thalweg is scoured by more than 3.5 feet from an elevation of +0.44 NAVD88 shown in the as-built plans to –3.2 ft in the recent survey.

8.0 REFERENCES

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Legend: Green line – Project Boundary

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Draft, August 2004
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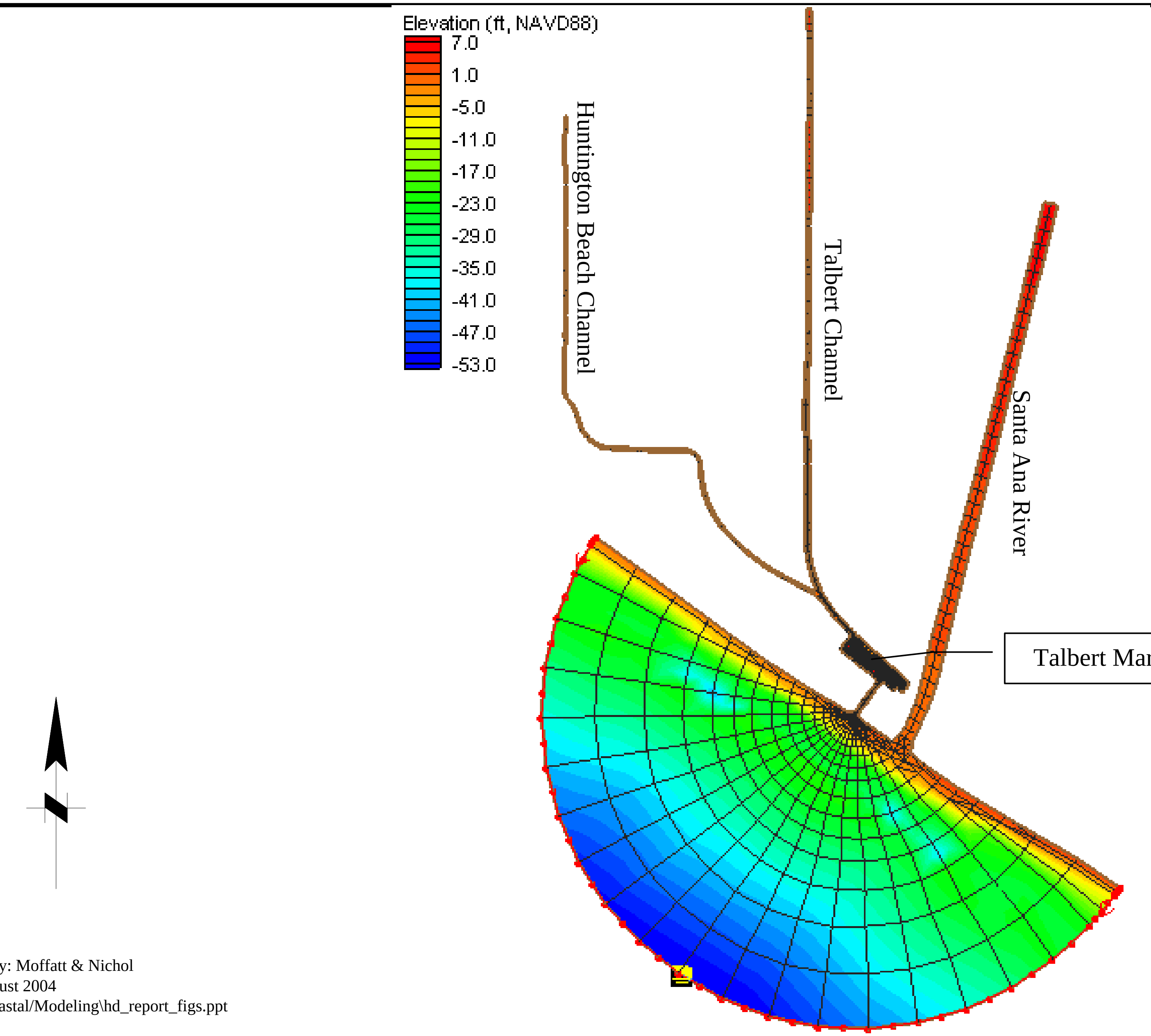
Huntington Beach Wetlands Conceptual Restoration Plan

Project Boundary Map

Figure 1



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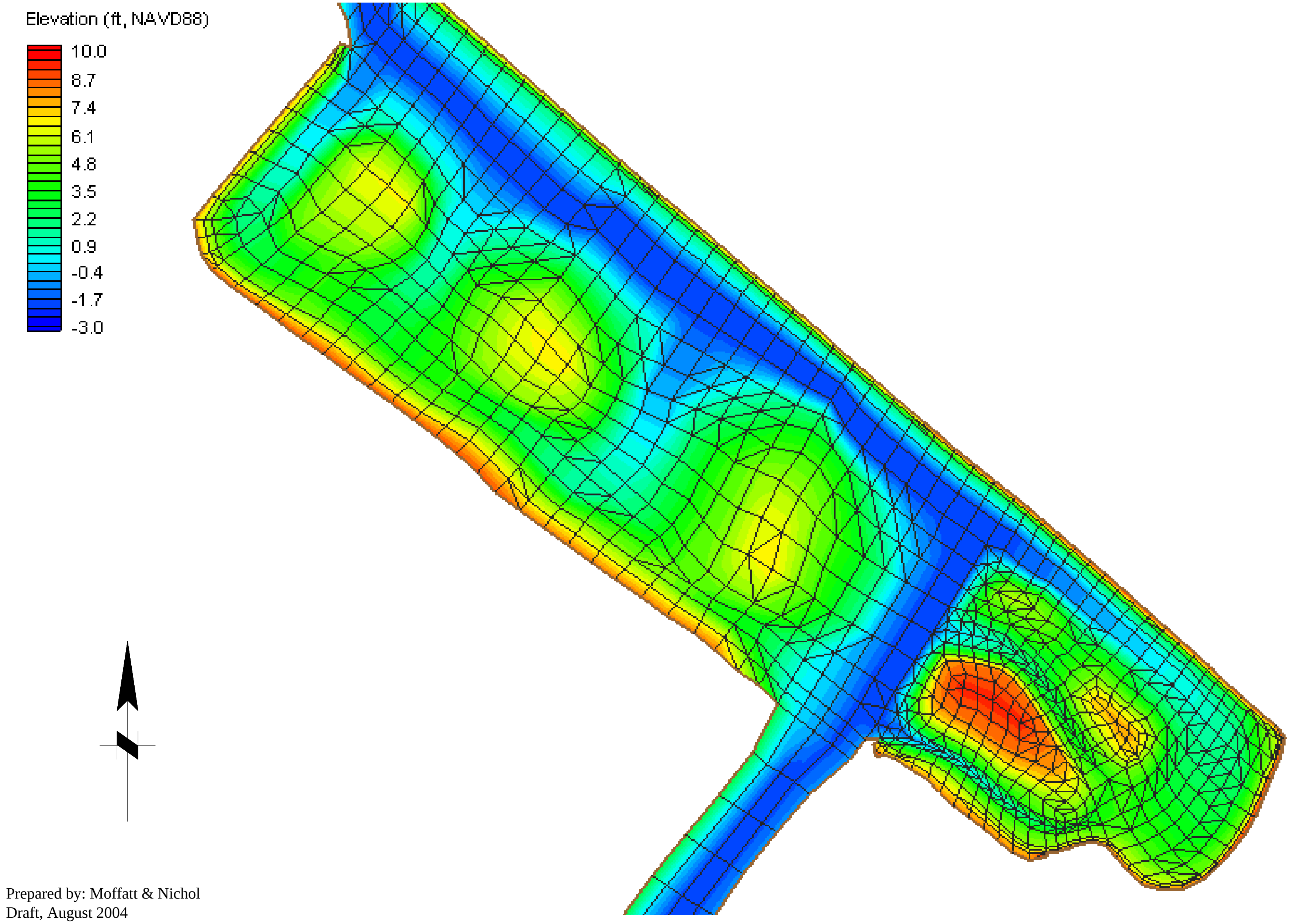
Huntington Beach Wetlands Conceptual Restoration Plan

Finite Element Mesh for the Existing Hydraulic System

Figure 2



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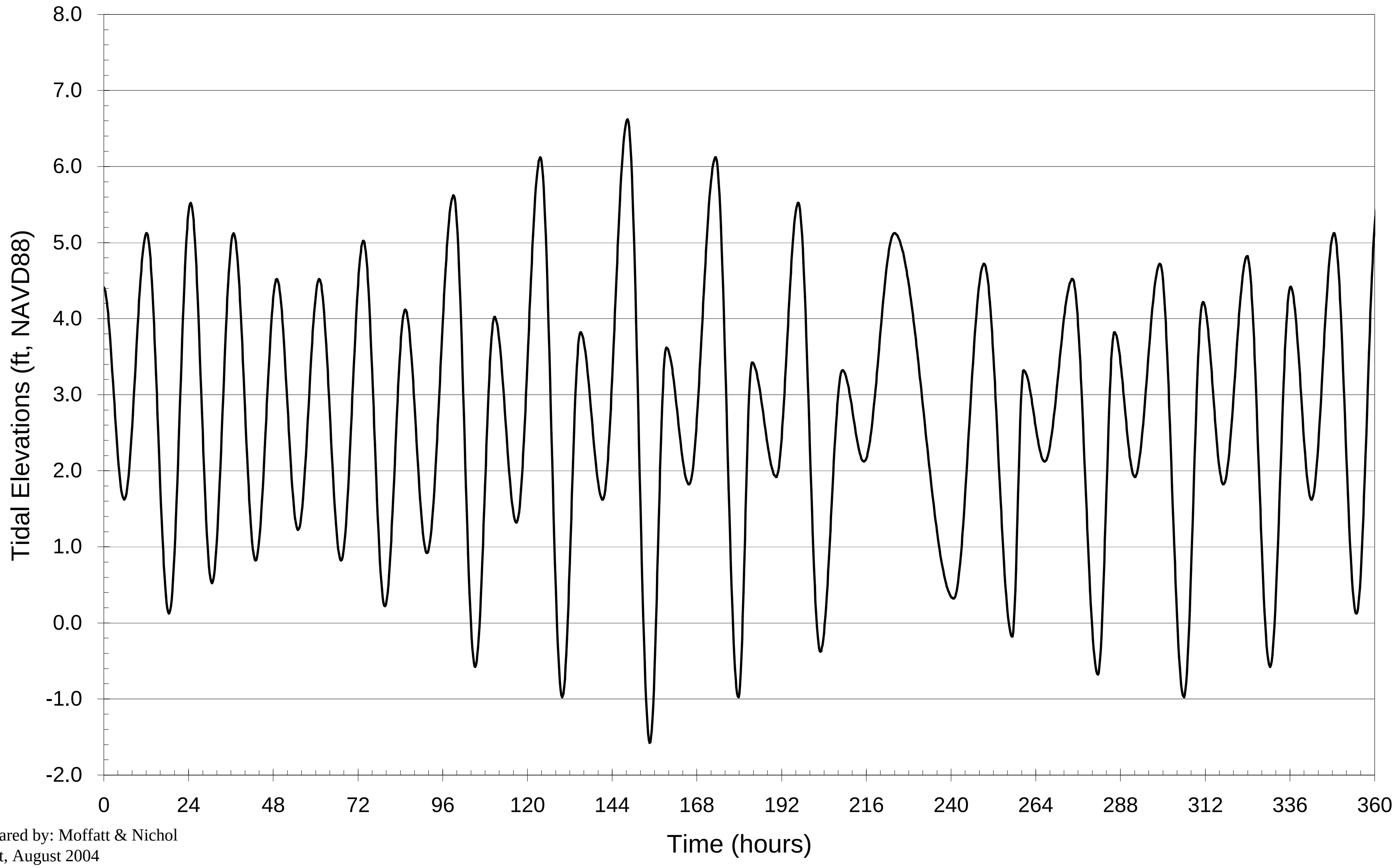
Huntington Beach Wetlands Conceptual Restoration Plan	Finite Element Mesh for Talbert Marsh	Figure 3



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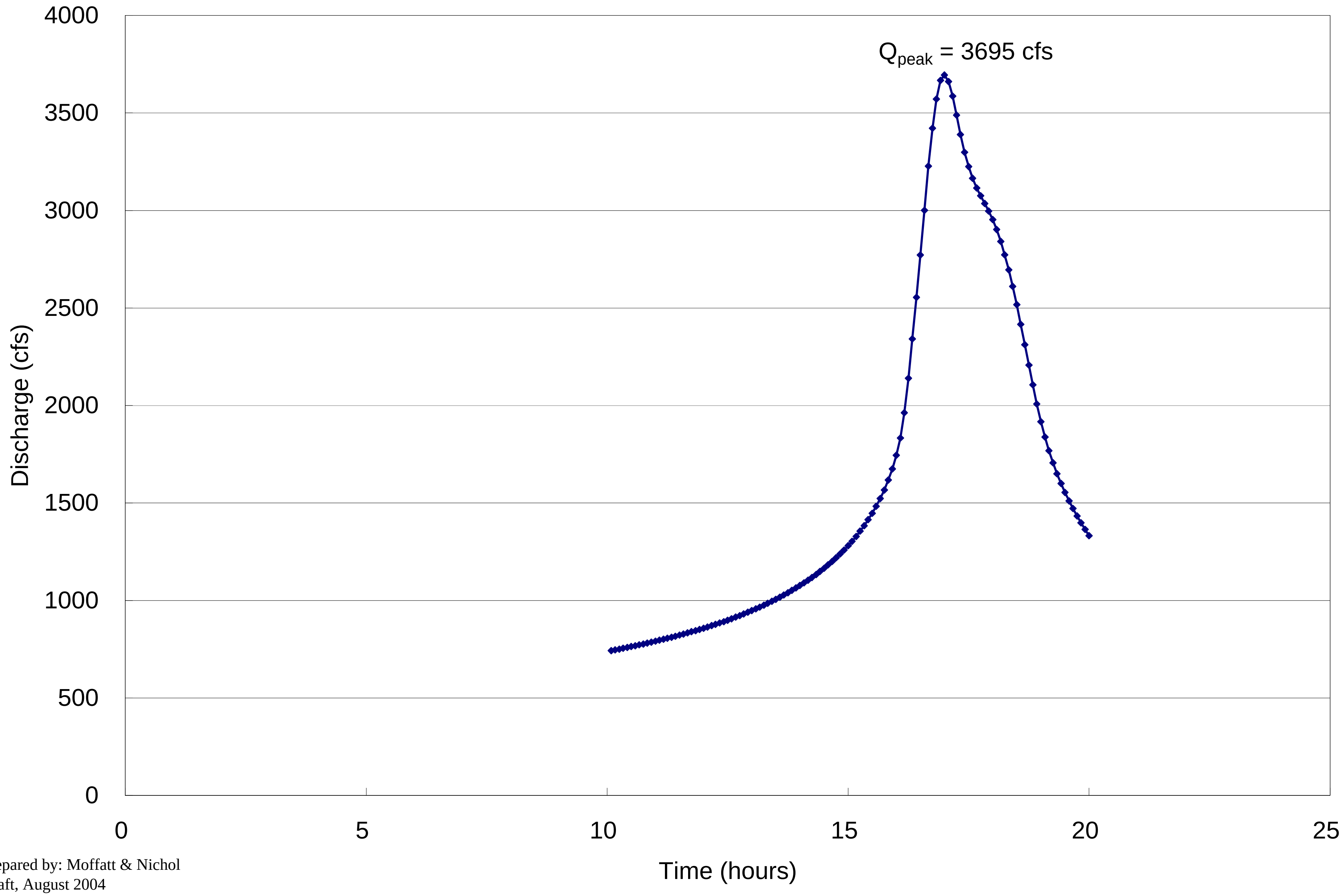
Huntington Beach Wetlands Conceptual Restoration Plan

Tidal Epoch Analyses (TEA) Tidal Series

Figure 4



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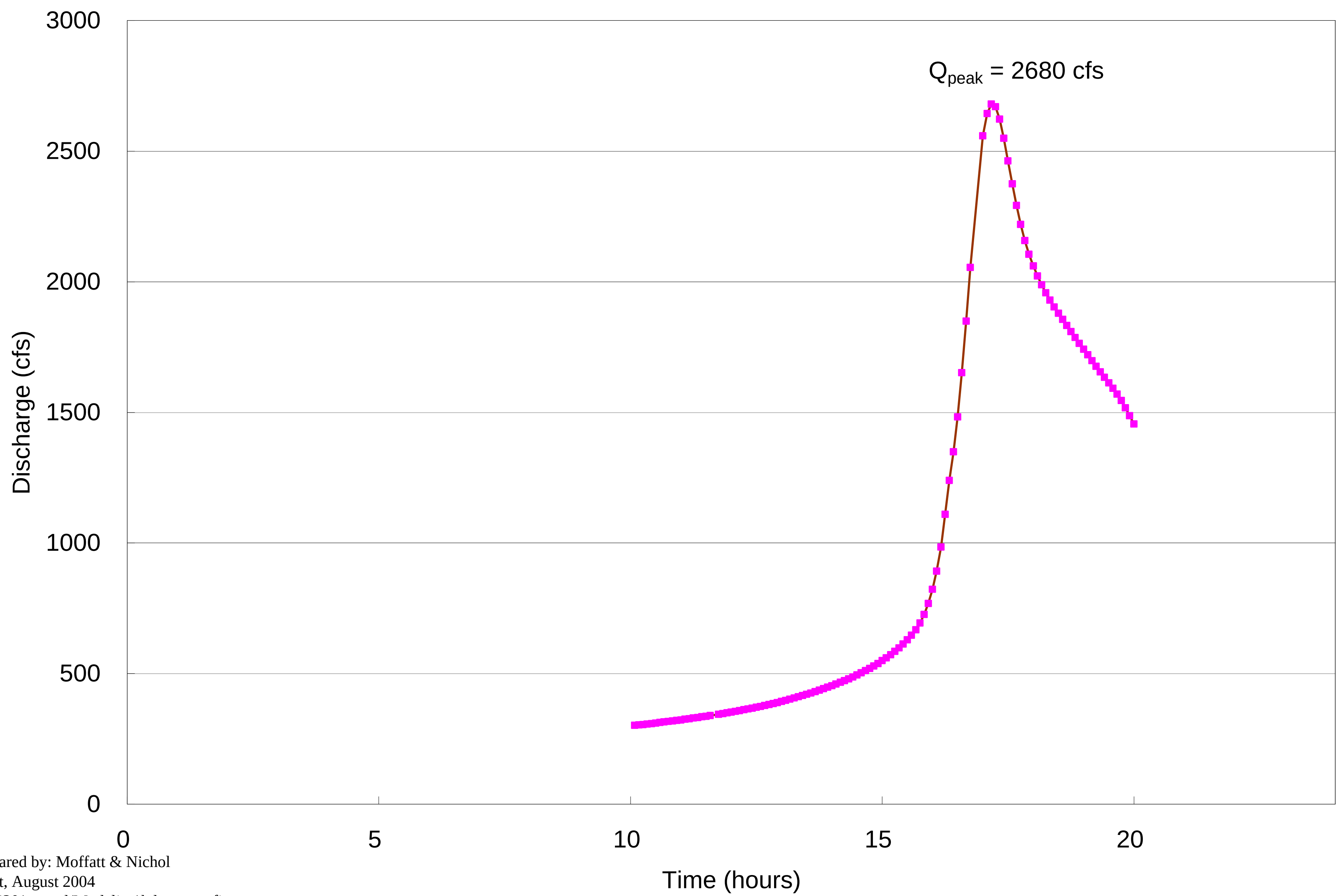
Huntington Beach Wetlands Conceptual Restoration Plan

100-Year Flood Hydrograph for the Huntington Beach Channel

Figure 5



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Huntington Beach Wetlands Conceptual Restoration Plan	100-Year Flood Hydrograph for the Talbert Channel	Figure 6

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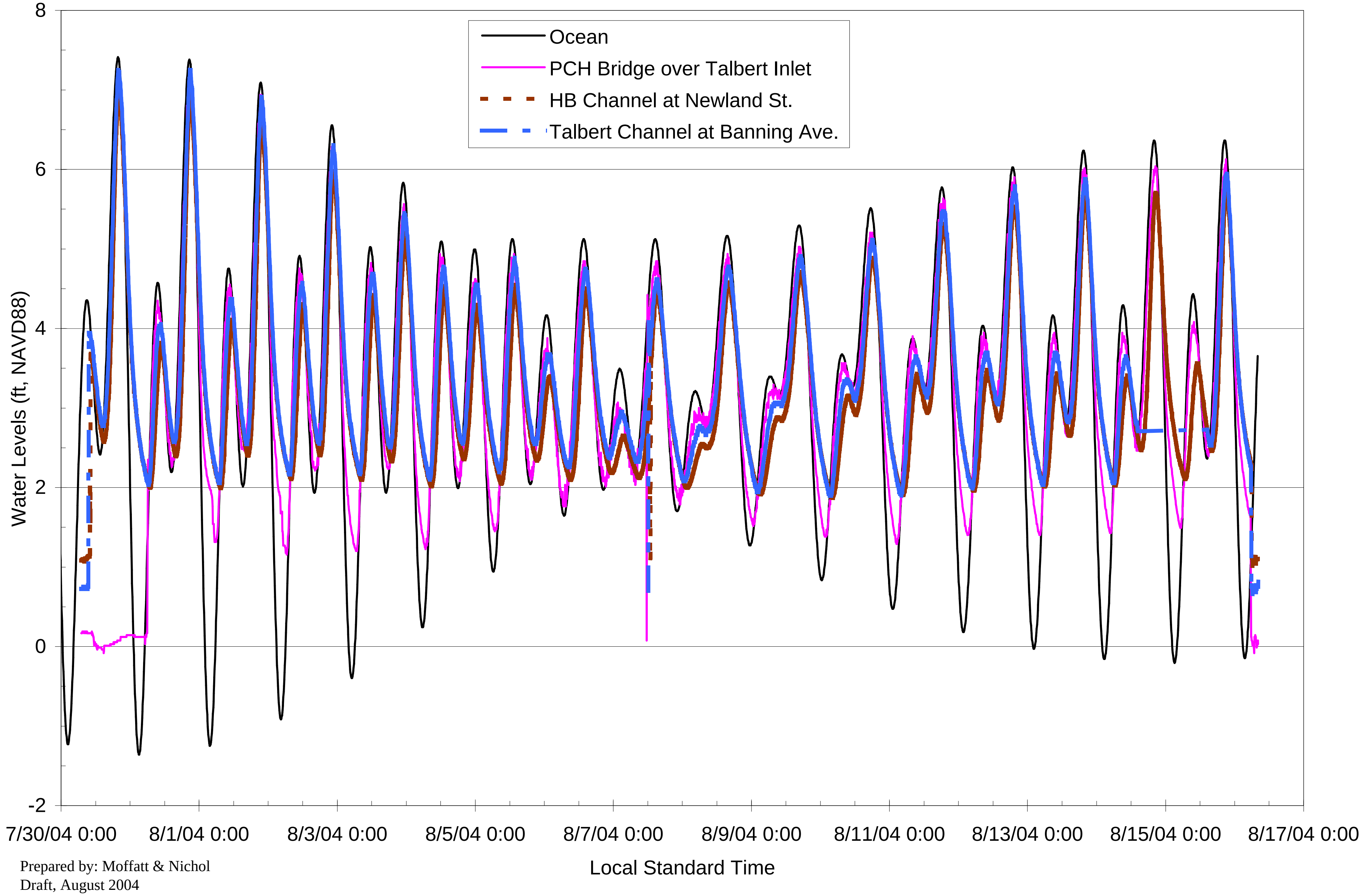
Map cited from Thomas Guide

Huntington Beach Wetlands Conceptual Restoration Plan	Tide Gage Locations	Figure 7



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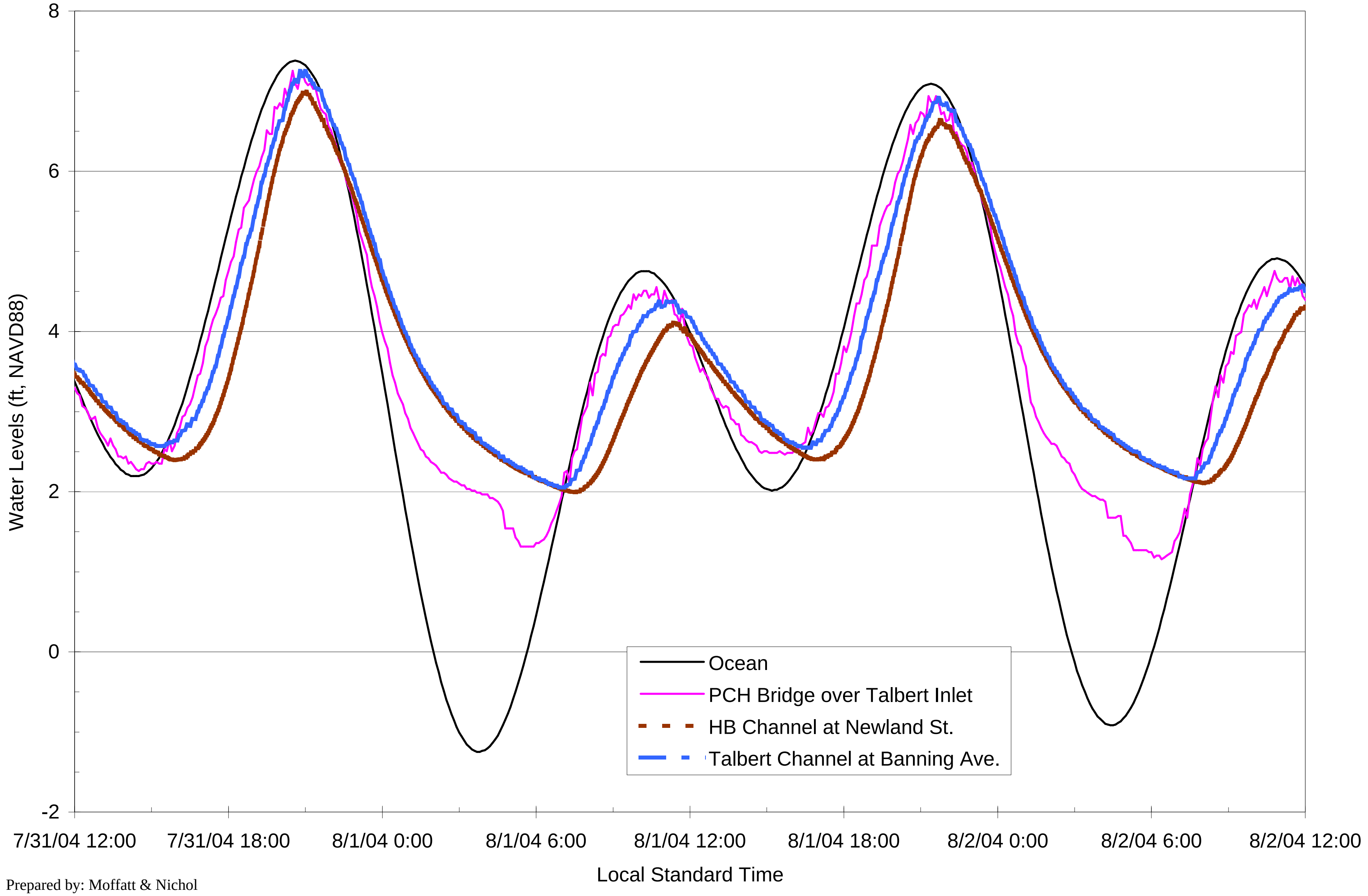
Huntington Beach Wetlands Conceptual Restoration Plan	Recorded Tidal Cycle	Figure 8



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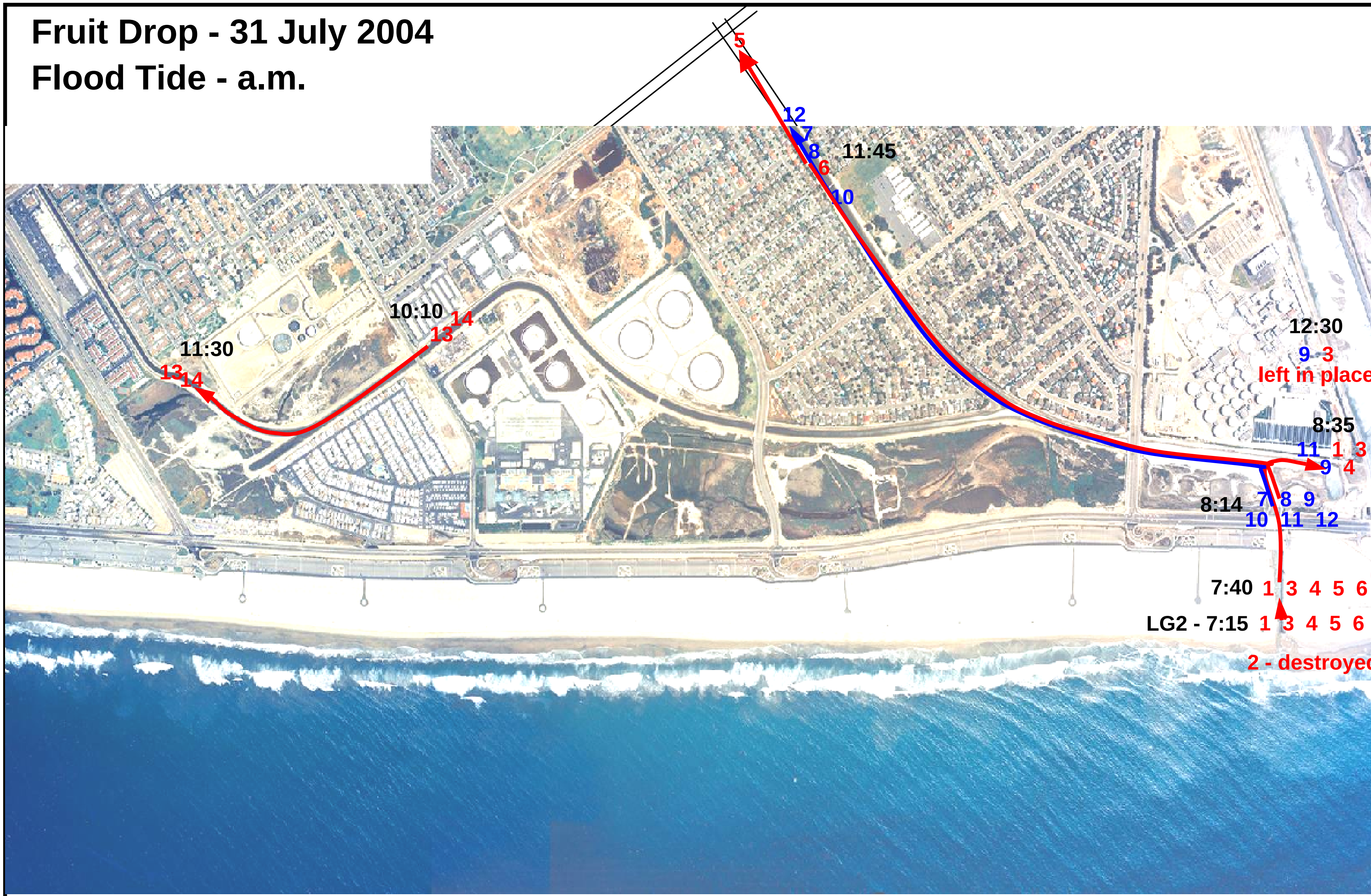
Huntington Beach Wetlands Conceptual Restoration Plan	Recorded Spring Tide Cycle	Figure 9

Fruit Drop - 31 July 2004
Flood Tide - a.m.



Prepared by: Moffatt & Nichol
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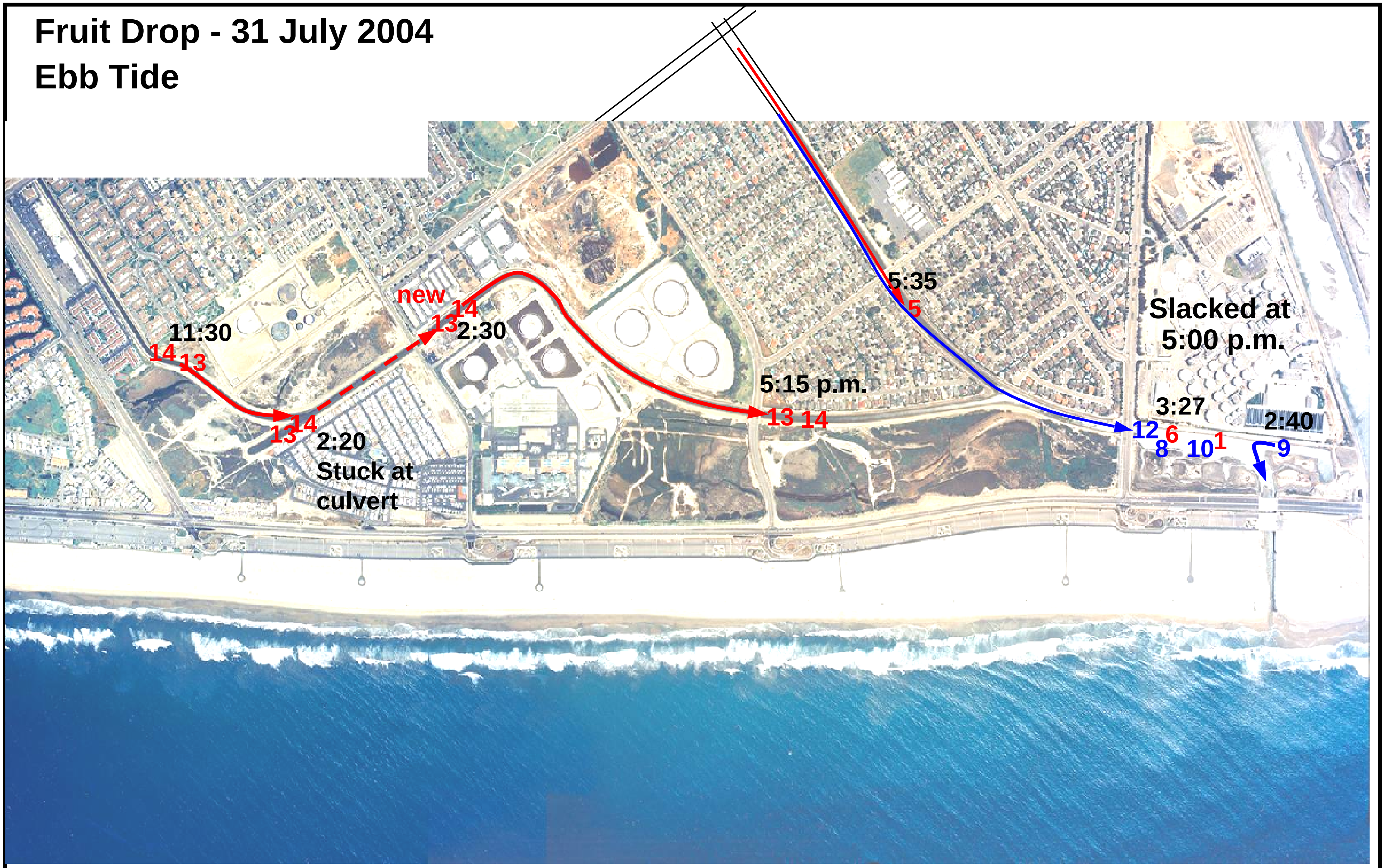
Huntington Beach Wetlands Conceptual Restoration Plan	Fruit Drop Map, Flooding Tide in the Morning on July 31, 2004	**Figure 10**

Fruit Drop - 31 July 2004
Ebb Tide



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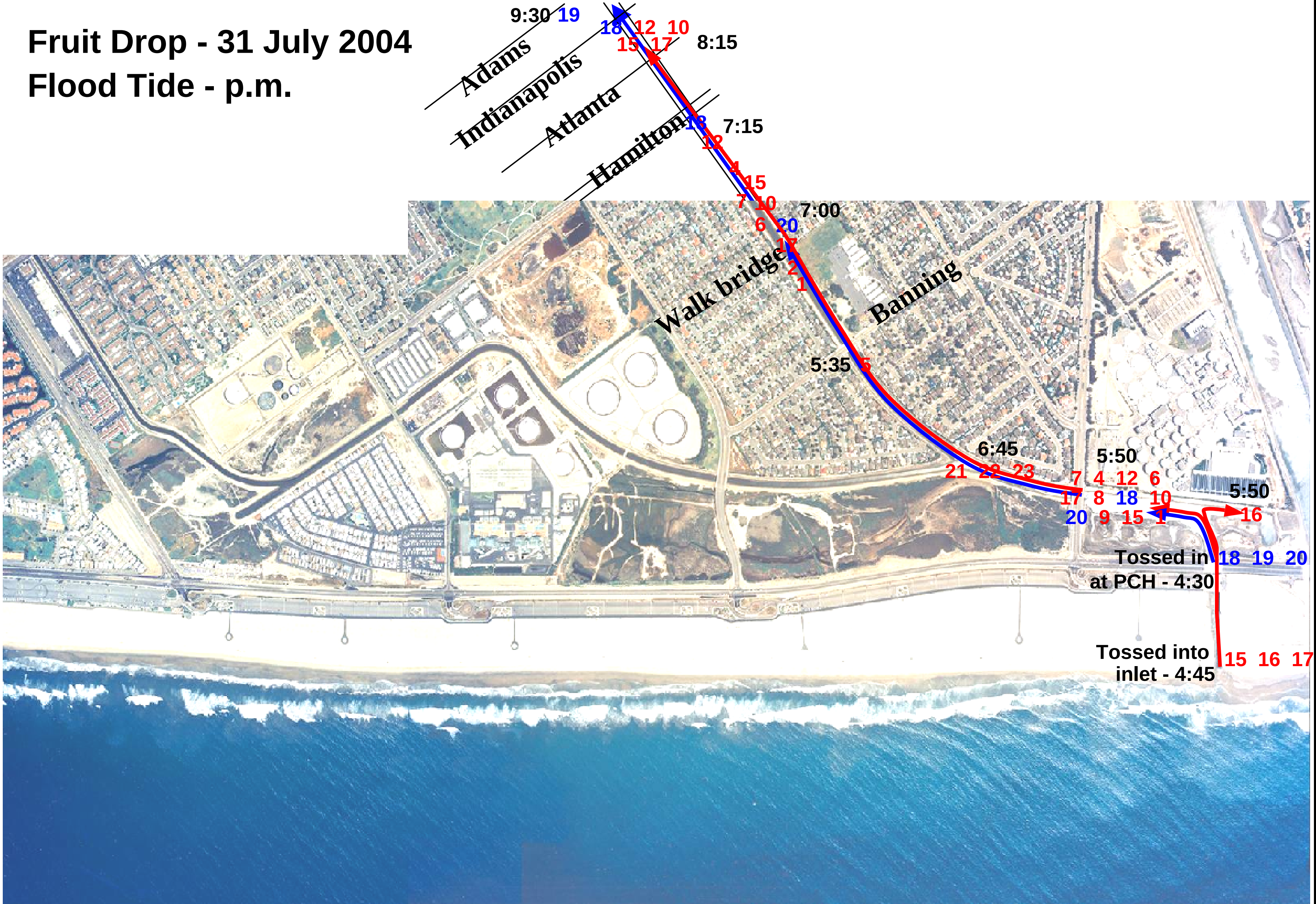
Huntington Beach Wetlands Conceptual Restoration Plan	Fruit Drop Map, Ebbing Tide in the Afternoon on July 31, 2004	Figure 11

Fruit Drop - 31 July 2004
Flood Tide - p.m.



Huntington Beach Wetlands Conceptual Restoration Plan	Fruit Drop Map, Flooding Tide in the Evening on July 31, 2004	**Figure 12**

A.M. - SLACK LOW TIDE	A.M. - HIGH TIDE				P.M. - LOW TIDE				P.M. - SLACK LOW TIDE	P.M. - HIGH TIDE				
Fruit in at PCH and Inlet	Talbert Channel	West Talbert Marsh	East Talbert Marsh	HB Channel	Talbert Channel	West Talbert Marsh	East Talbert Marsh	HB Channel	Fruit in at PCH and Inlet	Talbert Channel	West Talbert Marsh	East Talbert Marsh	HB Channel	*LOST*
1			1			1				1				
2														*damaged*
3			3											*3*
4			4							4				
5	5				5					5				
6	6					6				6				
7	7									7				
8	8					8				8				
9			9				9							
10	10					10				10				
11			11											
12	12									12				
13				13										*13*
14				14										*14*
									15	15				
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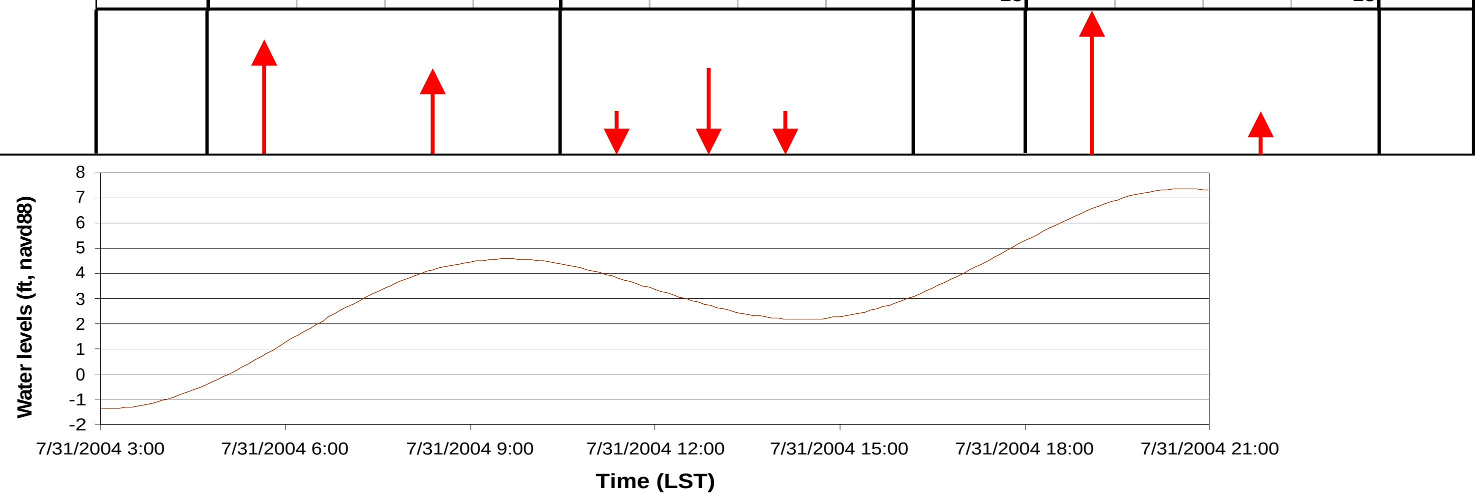

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Huntington Beach Wetlands Conceptual Restoration Plan

Fruit Drop Results Matrix

Figure 13